MORPHOLOGY AND ANATOMY OF *PAPENFUSSIELLA KUROMO* (CHORDARIACEAE, PHAEOPHYTA) FROM THE CANARY ISLANDS [1]

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ABSTRACT — *Papenfussiella kuromo* (Yendo) Inagaki (Chordariaceae, Phaeophyta) is reported for the first time from the Atlantic, at Tenerife, Canary Islands. Until now, this species was known only from Japan and China. Macrothalli of *Papenfussiella kuromo* are characterized by an outer dense medulla where abundant rhizoidal branched filaments occur, short cortical filaments curved and clavate, up to 10 cells in length, long cortical filaments hair-like of cylindrical cells and rounded apices and a weakly-developed subcortex formed by successive branching at the base of cortical filaments. A well defined layer of unilocular sporangia are formed from the subcortical cells. An isolectotype of *Myriocladia kuromo* Yendo as well as two specimens from Japan were compared with the Canary Islands plants.

RÉSUMÉ — *Papenfussiella kuromo* (Yendo) Inagaki (Chordariaceae, Phaeophyta), une espèce connue, jusqu'à présent, seulement du Japon et de Chine, est signalée pour la première fois sur les côtes atlantiques de Tenerife, aux îles Canaries. Les macrothalles de *Papenfussiella kuromo* sont anatomiquement caractérisés par des filaments médullaires externes compacts entre lesquels se développent de nombreux rhizoïdes ramifiés, des filaments corticaux courts, claviformes, arqués et dont la longueur peut atteindre 10 cellules, et des filaments corticaux longs, présentant l'aspect de poils et composés de cellules cylindriques ayant un sommet arrondi. Le caractère le plus remarquable est la formation d'une couche subcorticale, ce subcortex étant constitué par les divisions successives des cellules de la base des filaments corticaux. Les sporocystes uniloculaires naissent des cellules subcorticales et forment une couche bien définie. La morphologie et l'anatomie des spécimens des îles Canaries sont décrites et ces spécimens sont confrontés avec un isolectotype de *Myriocladia kuromo* Yendo ainsi qu'avec deux échantillons additionnels en provenance du Japon.

KEY WORDS: Marine benthic algae, *Papenfussiella*, Chordariaceae, Phaeophyta, Canary Islands, new record.

1. This paper is part of an unpublished degree Thesis (Martín, 1995 — *Estudio de las especies de Chordariaceae y Spermatochnaceae (Chordariales, Phaeophyta) en las Islas Canarias*. Tesis de Licenciatura, Universidad de La Laguna).

INTRODUCTION

The Chordariales (Phaeophyta) is worldwide in distribution, except for the Antarctic (Papenfuss, 1964). Within the *Myriogloia*-group of the Chordariaceae, Kylin (1940) described *Papenfussiella* to include species differing from those of *Myriogloia* Kuckuck and *Levringia* Kylin principally in the production of numerous rhizoidal filaments at the base of cortical filaments that, once developed, could hardly be differenciated from the inner medullary filaments. These genera have also been placed within Myriogloeaceae by Christensen (1980, p. 138).

The aim of this paper is to describe *Papenfussiella kuromo* (Yendo) Inagaki from the Canary Islands, a species known previously only from Japan (Inagaki, 1958) and China (Tseng, 1983). This species was described as *Myriocladia kuromo* by Yendo (1920, p. 1) and transferred to *Papenfussiella* by Inagaki (1958, p. 128) because of the absence of phaeophycean hairs and the presence of long and short cortical filaments, the latter embedded in gelatinous substance.

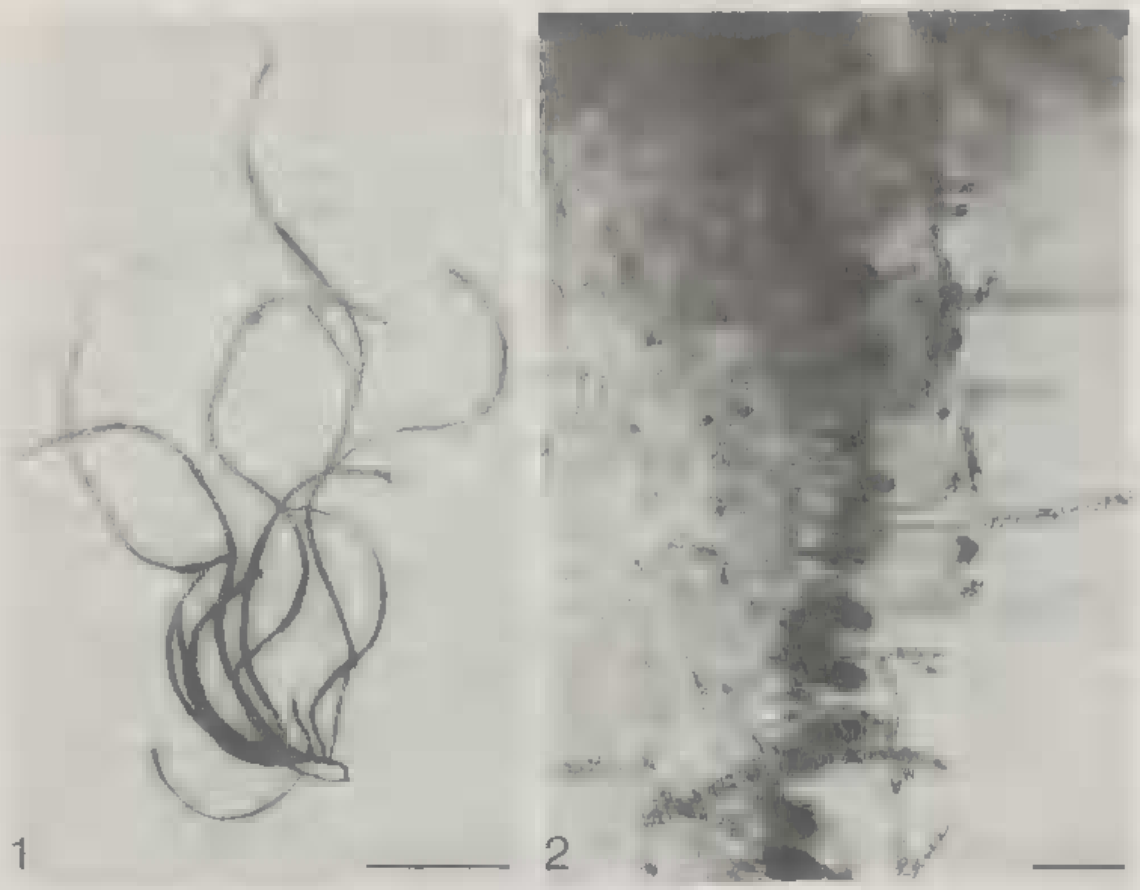
MATERIALS AND METHODS

Data were obtained from: (1) plants collected in Playa San Marcos, North Tenerife, Canary Islands and deposited at TFC [Departamento de Biología Vegetal (Botánica), Universidad de La Laguna, Canary Islands] with the numbers 8877 (12.06.1994; J. Reyes, E. Muñoz, M. Sansón), 8878 (13.06.1994; J. Reyes, E. Muñoz, M. Sansón) and 8906 (12.04.1995; J. Reyes, M. Sansón); (2) an isolectotype of *Myriocladia kuromo* deposited in SAP (Faculty of Science, Hokkaido University, Sapporo, Japan) with the number 060747 (12.03.1902; K. Yendo), collected at Sugashima, Japan; and (3) two specimens on the same herbarium sheet deposited at SAP with the number 058309 (30.03.1931; K. Inagaki), collected at Iragozaki, Japan. Morphological and anatomical observations were carried out on fragments fixed in 4% formalin in seawater. Selected small fragments of dried plants from the herbaria were rehydrated in 4% formalin in seawater and studied as slides prepared using 1% aniline blue. Drawings were obtained using a camera lucida attached to a Zeiss microscope. Micrographs were taken in a Zeiss photomicroscope.

RESULTS AND DISCUSSION

Specimens of *Papenfussiella kuromo* were collected at 4-5 m depth, growing on rocks settled on basaltic sandy bottom, together with other seasonal species of the genera *Acrosymphyton* Sjöstedt, *Dudresnaya* P. & H. Crouan, *Scinaia* Bivona-Bernardi and *Sporochnus* C. Agardh. Plants are erect, solid, subcartilaginous, slimy and cord-shaped (Fig. 1), up to 20 cm long, with a main axis to 4 mm in diameter arising from a small basal disc. Long lateral branches are irregularly arranged near the base of the main axis and produce a few short laterals. Numerous long cortical filaments cover the surface of branches, giving them a hairy appearance (Fig. 1).

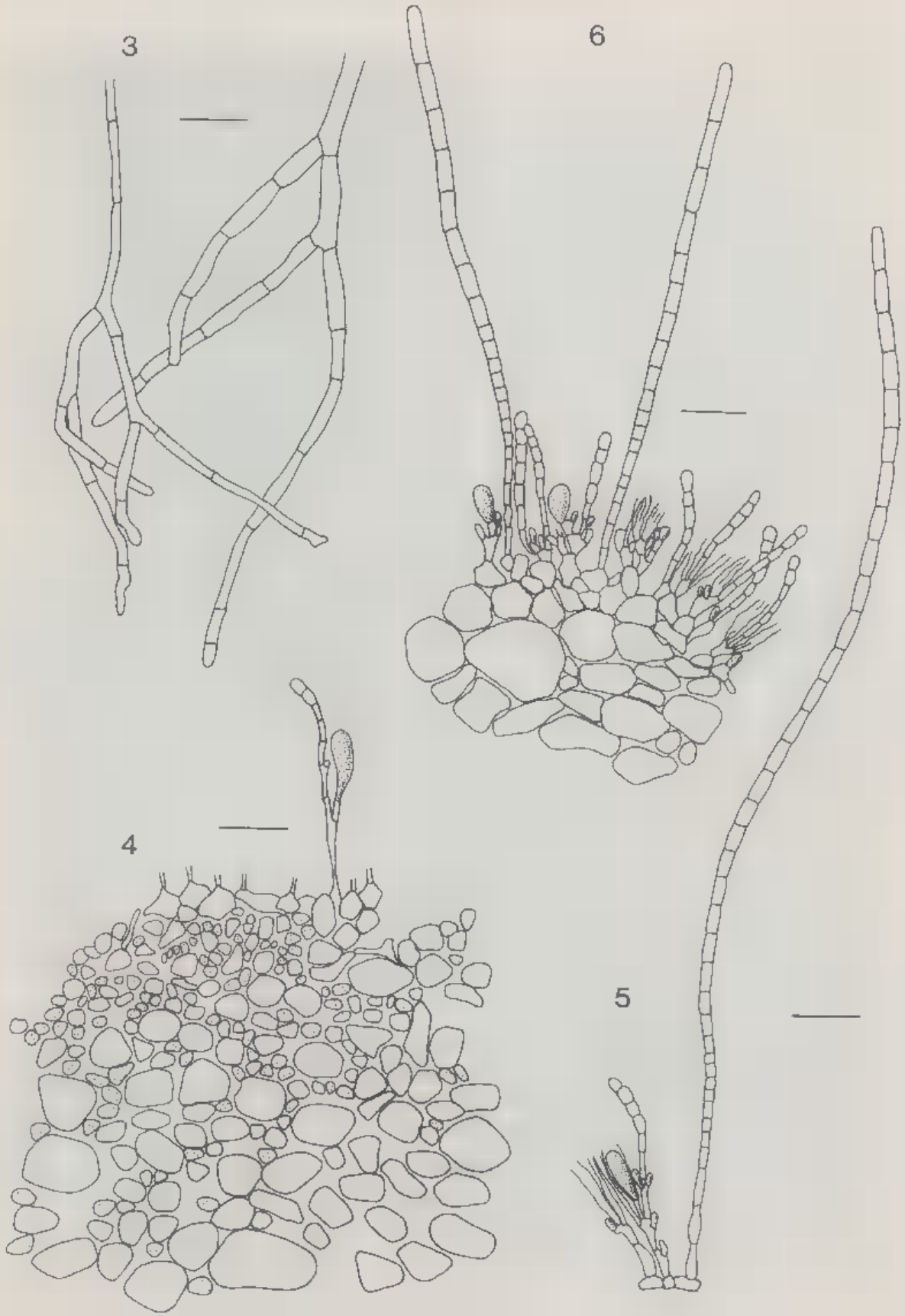
Anatomically, plants consist of an inner medulla, an outer medulla, a slight subcortex and a cortex. Inner medullary filaments are loosely arranged and are composed of ellipsoid to fusiform cells, 125-280 μm long and (37) 45-65 μm in dia-



Figs 1-2. *Papenfussiella kuromo* (Yendo) Inagaki. TFC 8877. Fig. 1. Habit. (Scale = 4 cm). Fig. 2. Transverse section of a branch, showing dense outer medullary cells. Note the continuous layer consisting of curved short cortical filaments and unilocular sporangia. (Scale = 50 μm).

meter, with smaller cells distally. Outer medullary filaments form a dense layer (Fig. 2), with ellipsoid to ovoid cells, 20-30 μm long and 17-23 μm in diameter. Branched rhizoidal filaments (Fig. 3) are abundant and intermingled with outer medullary filaments (Fig. 4). Rhizoidal filaments are borne at the base of cortical filaments, subcortical cells or, occasionally, outer medullary cells. Subcortical filaments consist of 1-3 clavate cells, bearing short cortical filaments distally (Figs 5-6). Two kinds of cortical filaments are present. Long cortical filaments are hair-like, to 2.5 mm long with up to 55 cells, cylindrical, with a division zone near their base (Fig. 5). Short cortical filaments are simple, curved, club-shaped, 60-120 μm long, composed of 5-8 cells, and densely cover the surface of branches (Fig. 5). Proximal cells of these filaments are cylindrical, (10) 17-25 μm long and up to 5 μm in diameter; the distal ones are ovoid to subspherical, to 15 μm long and 8 μm in diameter. Unilocular sporangia, ovoid to pyriform, (35) 42-68 μm long and 10-25 μm in diameter, are abundant and formed singly or in pairs from the distal ends of subcortical cells (Figs 2, 6).

Examination of an isolectotype of *Myriocladia kuromo* (SAP 060747) has allowed us to confirm the identity of the Canarian plants. The isolectotype specimen



(Fig. 7) is 23 cm long, with a small basal disc from which arise a main axis, 2 mm in diameter, with numerous primary branches, 1.5-2 mm in diameter, arranged irregularly alternately bearing few secondary short branches. The plant is abundantly covered with long cortical filaments on the entire surface of the branches. The dimensions and morphology of cells are similar to the material from the Canary Islands plants. Only a few empty sheaths of sporangia were detected.

Two other specimens from Japan (SAP 058309) have also been studied (Fig. 8). One is 29 cm long, with a small basal disc from which two main axes arise, the longest one 3.5 mm in diameter with several short branches, from 250 µm to 1 mm broad. No sporangium was observed. The other is 27.5 cm long, with a small basal disc and consist of five main axes, 1-3 mm in diameter. Two axes have abundant lateral branches to 1.5 mm in diameter, the rest have only a few short branches. This plant bears numerous ovoid to pyriform unilocular sporangia borne on subcortical cells.

Papenfussiella includes seven species: *P. callitricha* (Rosenvinge) Kylin, *P. extensa* Womersley *et* Bailey, *P. gracilis* Kylin, *P. kuromo* (Yendo) Inagaki, *P. laxa* Kylin, *P. lutea* Kylin and *P. tristanensis* Kylin (Kylin, 1940; Womersley, 1987). These species (Table 1) are mainly segregated by habit, morphology, and cellular dimensions of long and/or short cortical filaments. Specimens from the Canary Islands are in good agreement with *Papenfussiella kuromo* (Inagaki, 1958) and the Japanese specimens examined. Inagaki (1958) pointed out the absence of a subcortical layer in this species, although according to his drawings (Inagaki, 1958, p. 132, Fig. 38 D-F, Fig. 39 A) there was a slight subcortex of 1-3 clavate hyaline cells at the base of short cortical filaments from which unilocular sporangia are laterally arranged. This also has been observed in specimens studied from Japan and the Canary Islands (Fig. 5). This feature separates *Papenfussiella kuromo* from the rest of the species.

P. kuromo also differs from other Atlantic species in morphology and cellular dimensions of long cortical filaments (Table 1), being in this species cylindrical and with cells to 7 times as long as broad, 4.5-6 µm in diameter. *P. gracilis*, reported from western South Africa, has long cortical filaments with cells being suddenly broader, up to 15-20 µm in diameter, above the meristem (Kylin, 1940). *P. laxa*, also known from Western South Africa (Kylin, 1940), has long cortical filaments being progressively broader in the middle and then narrower towards the apices, with cells to 1.5 times as long as broad, showing slight constrictions between two successive cells. *P. tristanensis* is poorly known and has only been reported from the type locality, Seal Bay at Tristan da Cunha (Kylin, 1940), showing long cortical filaments with cells 1-1.5 times as long as broad, 10-15 µm in diameter. In *P. callitricha* the long cortical filaments are similar to those of *P. kuromo* but it has a subarctic distribution and the macrothallus do not grow at temperatures higher than 8°C (Hooper & South, 1977; Peters, 1984).

Figs 3-6. *Papenfussiella kuromo* (Yendo) Inagaki, TFC 8877. Fig. 3. Branched rhizoidal filaments. (Scale = 50 µm). Fig. 4. Detail of a transverse section of a branch, showing the arrangement of rhizoidal filaments (pointed cells) between outer medullary cells. (Scale = 50 µm). Fig. 5. Detail of a long cortical filament and a short one with unilocular sporangia arising from distal ends of subcortical cells. Note the presence of some empty sheaths of sporangia. (Scale = 50 µm). Fig. 6. Detail of a transverse section of a branch, showing long and short cortical filaments and several unilocular sporangia arising from subcortical cells. (Scale = 50 µm).

CHARACTERS	*P. KUROMO* this study	*P. KUROMO* Inagaki, 1958	*P. LUTEA* Kylin, 1940	*P. LUTEA* Womersley, 1987	*P. EXTENSA* Womersley, 1987
Medullary cells					
Diameter	(37)-45-63	-	-	10-16-(20)	10-22
L/D	2-4-(7)	-	-	(4)-6-12-(15)	2-4-(6)
Short cortical filaments					
Morphology	very curved	very curved	very curved	right or slight. curved	slight. curved
Length	60-120	50-100	100-150	100-250	30-60
Number of cells	5-8	6-10	8-12	10-20	(4)-6-12
Diameter basal cells	5	-	-	< apical cells	< apical cells
Diameter apical cells	8	-	8-10	(6)-8-10	4-6
Long cortical filaments					
Morphology	cylindrical	cylindrical	cylindrical	torulose above meristem	cylindrical
Length (mm)	2-2.5	1-2	1-1.5	1-1.5	1-2.5
Number of cells	up to 55	-	-	up to 50	up to 50
Diameter basal cells	4.5-6	-	10-15	< apical cells	(7)-8-10
L/D basal cells	3-5	-	1-2	-	1-1.5
Diameter apical cells	(7)-10-13	-	6-8	15-20	-
L/D apical cells	4.5-7-(8.5)	-	3-4	1.5-2	3-4
Unilocular sporangia					
Origin	subcortical cells	subcortical cells or base of cortical filaments	(*) outer medullary cells or base of cortical filaments	outer medullary cells or rhizoidal cells	outer medullary cells or base of cortical filaments
Length	(35)-42-68	20-40	55-65	(40)-45-70-(95)	(30)-40-50
Diameter	10-25	20-40	30-35	15-30	16-24

Table 1. Comparison of characters in *Papenfussiella* species. (*) = Data obtained from drawings. All measurements in μm. L/D = length/diameter ratio.

P. lutea and *P. extensa* have been reported from New Zealand, Tasmania and southern Australia (Kylin, 1940; Womersley, 1987). *P. lutea* differs from *P. kuromo* in the origin of unilocular sporangia, arising directly from outer medullary filaments or from rhizoidal filaments in *P. lutea* (Womersley, 1987), whereas in *P. kuromo* they borne on subcortical cells. Finally, *P. extensa* has shorter and thinner short cortical filaments as well as thinner long ones, than any other species of the genus (Womersley, 1987).

Until now, *Papenfussiella kuromo* was known only from Japan and China (Zhejiang Province; Tseng, 1983). The presence of *Papenfussiella kuromo* at the Canary Islands seems quite surprising. According to Womersley (1987, p. 109), species of *Papenfussiella* are separated mainly on robustness and cell diameters and proportions in the long cortical filaments, and this is not clear cut between some of the species which are poorly-known. In this sense, the geographical distribution of some species of *Papenfussiella* may be much wider than actually known. We think that this species has not been newly introduced in the Canary Islands but rather has not been collected up to now, due to (1) the short seasonal occurrence of the macrothallus, (2) the unstable

CHARACTERS	*P. CALLITRICHA* Kylin, 1940	*P. CALLITRICHA* Wilce, 1969	*P. GRACILIS* Kylin, 1940	*P. LAXA* Kylin, 1940	*P. TRISTANENSIS* Kylin, 1940
Medullary cells					
Diameter	-	15-33	-	-	-
L/D	-	-	-	-	-
Short cortical filaments					
Morphology	-	-	-	-	-
Length	-	up to 80	-	-	-
Number of cells	-	-	-	-	-
Diameter basal cells	-	7-11	-	-	-
Diameter apical cells	-	10-16	-	-	-
Long cortical filaments					
Morphology	cylindrical	-	suddenly broader above meristem	progressively broader above meristem	slightly broader above meristem
Length (mm)	1.5-2.5	-	1-2	1-1.5	1-1.5
Number of cells	-	-	-	-	-
Diameter basal cells	-	-	15-20	25-30	10-15
L/D basal cells	1-2	-	0.5-1	0.5-1	1-1.5
Diameter apical cells	-	-	8	12-15	6-8
L/D apical cells	3-5	-	1-1.5	1-1.5	2-2.5
Unilocular sporangia					
Origin	-	base of cortical filaments	(*) base of cortical filaments	(*) outer medullary cells = base of cortical filaments	-
Length	-	52-71	90-110	110-130	70-90
Diameter	-	19-30	30-40	35-45	25-35

Table 1 (continuation). Comparison of characters in *Papenfussiella* species. (*) = Data obtained from drawings. All measurements in µm. L/D = length/diameter ratio.

habitat where this species grows (on scattered rocks established on sandy bottoms), and (3) the small number of individuals forming populations of the species. Furthermore, *Papenfussiella* grows far away from harbours which are the main points of introduction of species.

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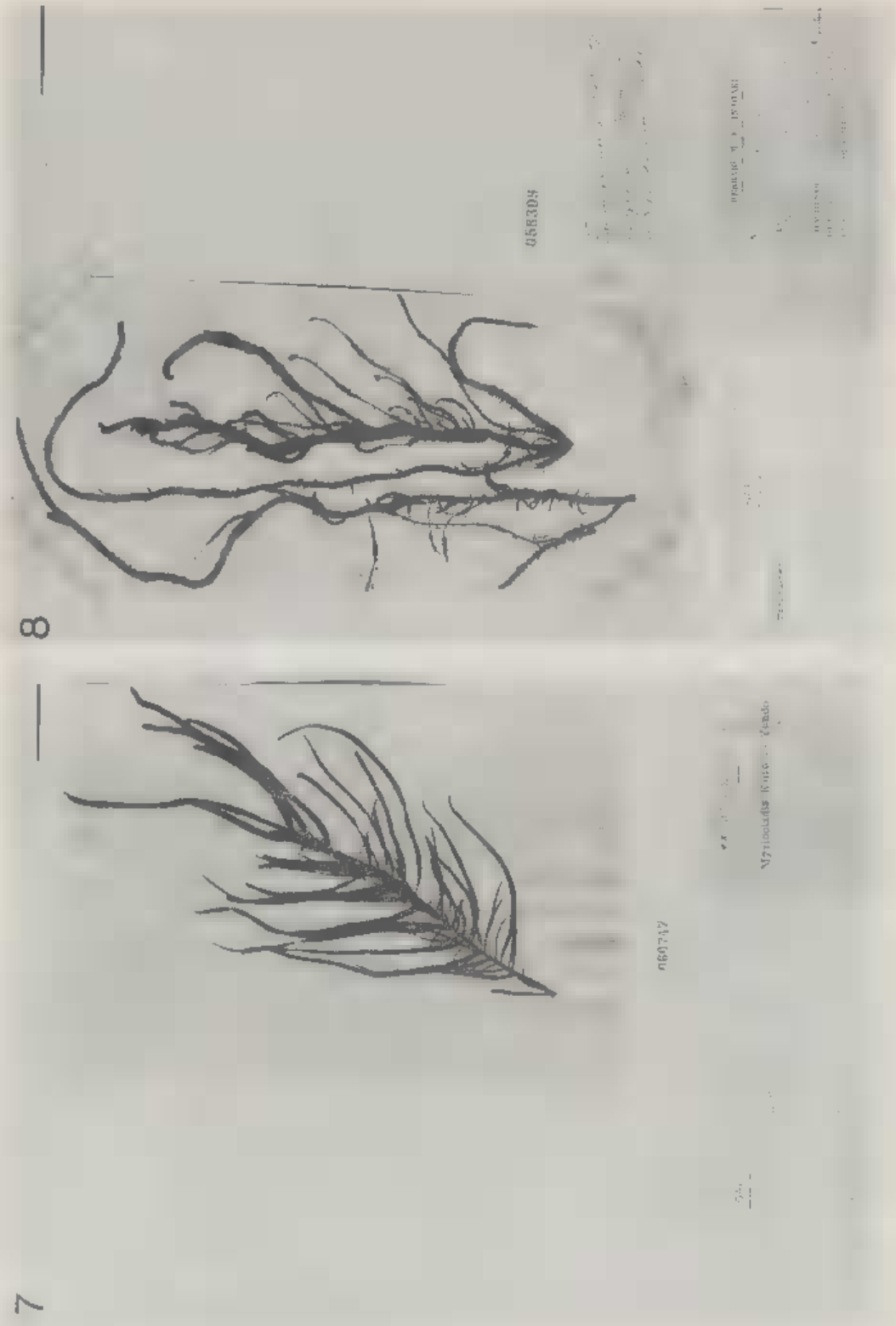

Figs 7-8. Fig. 7. Isolectotype of *Myriocladia kuromo* Yendo. SAP 060747. (Scale = 5 cm). Fig. 8. *Papenfussiella kuromo* (Yendo) Inagaki. SAP 058309. (Scale = 5 cm).

REFERENCES

CHRISTENSEN, 1980 — *Algae. A taxonomic survey*. Odense, AiO Print Ltd., [i-iv]-xi, 1-472.

HOOPER R. & SOUTH G.R., 1977 — Distribution and ecology of *Papenfussiella callitricha* (Rosenv.) Kylin (Phaeophyceae. Chordariaceae). *Phycologia* 16: 153-157.

INAGAKI K., 1958 — A systematic study of the order Chordariales from Japan and its vicinity. *Scientific Papers of the Institute of Algological Research, Faculty of Science, Hokkaido University* 4: 87-197, pls 1-11 + legends.

KYLIN H., 1940 — Die Phaeophyceenordnung Chordariales. *Acta University Lund. N. F.* 2 (36): 1-67.

PAPENFUSS G.F., 1964 — Catalogue and bibliography of Antarctic and Sub-Antarctic benthic marine algae. [*In*: LEE M. O. (ed.), Biology of the Antarctic seas]. *Antarctic Research Series* 1: 1-76.

PETERS A.F., 1984 - Observations on the life history of *Papenfussiella callitricha* (Phaeophyceae, Chordariales) in culture. *Journal of Phycology* 20: 409-414.

TSENG C.K. (ed.), 1983 - *Common Seaweeds of China*. Beijing, China, Science Press, i-x, [1]-316.

WILCE R.T., 1969 — *Papenfussiella callitricha*: New observations on a little-known endemic brown alga from Southwest Greenland. *Journal of Phycology* 5: 173-180.

WOMERSLEY, H.B.S., 1987 - *The marine benthic flora of Southern Australia. Part II*. Adelaide, D.J. Woolman, South Australian Government Printing Division, 484 p.

YENDO K., 1920 — Novae Algae Japoniae. Decas I-III. *The Botanical Magazine* (Tokyo) 34: [1]-12.